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Volume 15 February, 1929 *Number 2*

Lubrication

A Technical Publication Devoted to
the Selection and Use of Lubricants

THIS ISSUE

Lubrication of
Automatic Coal Firing
Machinery

PUBLISHED MONTHLY BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

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Published Monthly by

The Texas Company, 17 Battery Place, New York City

Vol. XV February, 1929 No. 2

Lubrication of Automatic Coal Firing Machinery

IN connection with the extensive efforts which are being devoted by combustion engineers towards improving coal handling machinery, and increasing fuel economy, it is decidedly essential to study the lubrication requirements of the equipment involved.

The purpose of automatic coal firing machinery is two-fold, viz.: to decrease the cost of handling and stoking, and to increase the rate of evaporation or steam generating efficiency. From an economic point of view, the ultimate result should be a decrease in fuel consumption, which should react favorably throughout all parts of the plant where coal handling or storage may be involved.

To assure these results, however, all machinery employed must be capable of functioning at a maximum rate of efficiency, with power consumption reduced to a minimum. As originally designed, the products of the reputable stoker and pulverizer manufacturers can be depended upon as being capable of such operation, but continued service can only be attained by observing every precaution to insure effective lubrication.

It is obvious that if an adequate supply of the proper grade of lubricant is positively delivered to each wearing element, the possibility of solid or metal-to-metal friction will be reduced, with a corresponding decrease in the amount of power consumed in operation. Virtually, this will constitute a matter of power consumption reduction at the source.

EQUIPMENT INVOLVED

For the mechanical handling or firing of solid fuels, there are two distinct types of equipment available, viz.:

The coal pulverizer, and
The automatic stoker.

While the purpose involved is essentially the same in both, their construction and manner of operation will be distinctly different. The former, for example, provides for the firing of coal under pressure in proper mixture with air, after it has been reduced to a comparatively uniform degree of fineness in the pulverizing element; the stoker, on the other hand, delivers coal to the grates just as it comes from storage, in frequently a wide variety of sizes.

PULVERIZER CONSTRUCTION AND OPERATION

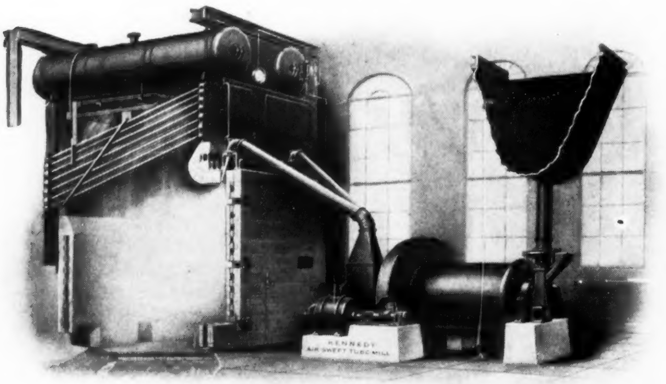
The firing of pulverized coal involves the use of either the bin or storage system, or the unit system, wherein there is usually one pulverizer per boiler. The latter in general requires less equipment, and, from the viewpoint of lubrication, at least, is the more simple of the two. Both embody the same basic principle, i. e., the pulverization of coals to a sufficient extent to permit of firing in the form of a powder.

The Unit System

In the unit system the pulverizer is the outstanding piece of equipment from an operating as well as a lubricating point of view. Other apparatus involved may comprise a separator, a fan for secondary air supply, and the necessary driving motors.

The Bin System

The Bin system, in turn, usually involves, in addition to the pulverizer, such machinery as a dryer, dryer fan, conveyor, exhaust fan for use in connection with the pulverizer, a cyclone separator or dust collector, oftentimes an air compressor, a coal feeder blower and the necessary driving motors. All of these contain bearings which require careful attention to lubrication.



Courtesy of Kennedy-Van Saun Mfg. & Eng. Corp.

Fig. 1—Cut-away view of a pulverized coal burning installation, involving a Kennedy air-swept tube mill. Note the relation of the pulverizer to coal storage and boiler. An essential feature of the operation of such a mill is to maintain effective lubrication of the herring-bone gears which are shown in the cut-away.

Function of the Pulverizer

Of the above equipment, the pulverizer being of outstanding importance, will require a certain amount of discussion and explanation. Essentially it consists of a horizontal or vertical rotating and pulverizing element mounted on a shaft, the whole being contained within a suitable housing.

According to the design the pulverizing element or rotor may be constructed to perform its intended function in one or more stages, frequently being fitted at one end with a suitable fan which draws in sufficient air to carry the coal through the system, and aid in bringing about combustion. Actual breaking up or pulverization of the coal is accomplished by swing hammers, rings, tubes, balls or suitable rolls in conjunction with the crushing surface of the housing.

The pulverizer is frequently subjected to the most severe service conditions and, therefore, may involve some decided lubricating problems. Coal dust is continually present, sulphurous products which will tend to react with water to form corrosive acids may have to be handled, and dampness frequently prevails. All of these are detriments to operation, in that the least failure in a lubricating system may cause scoring or corrosion of the rotor bearings, or the wearing elements in other equipment. Such conditions will lead to more or less solid or metallic friction due to faulty lubricating films between the moving parts in question, causing an increase in power consumption and ultimately the necessity for repair or replacement.

STOKER DESIGN

The mechanical stoker is also a practical and efficient means of overcoming the difficulties of hand firing.

According to the principle involved, or the means by which the coal is delivered to the furnace, mechanical stokers are known respectively as

(a) the overfeed
(b) the underfeed or
(c) the traveling or chain grate type.

The mechanism of the modern stoker is relatively simple in design, the driving unit being the essential part requiring lubrication. Individual manufacturers, however, employ various adaptations or types of drives according to the operating requirements of their stokers. In studying stoker lubrication we must, as a result, look into the several designs or basic types in use today, inasmuch as lubrication will be materially contingent upon gear and bearing construction and the means provided for applying the lubricants.

Types of Stokers

The overfeed type

In the Overfeed Stoker coal is fed in at the sides, or at the front end of the furnace through a hopper or magazine, being distributed along the top of an inclined set of grates.

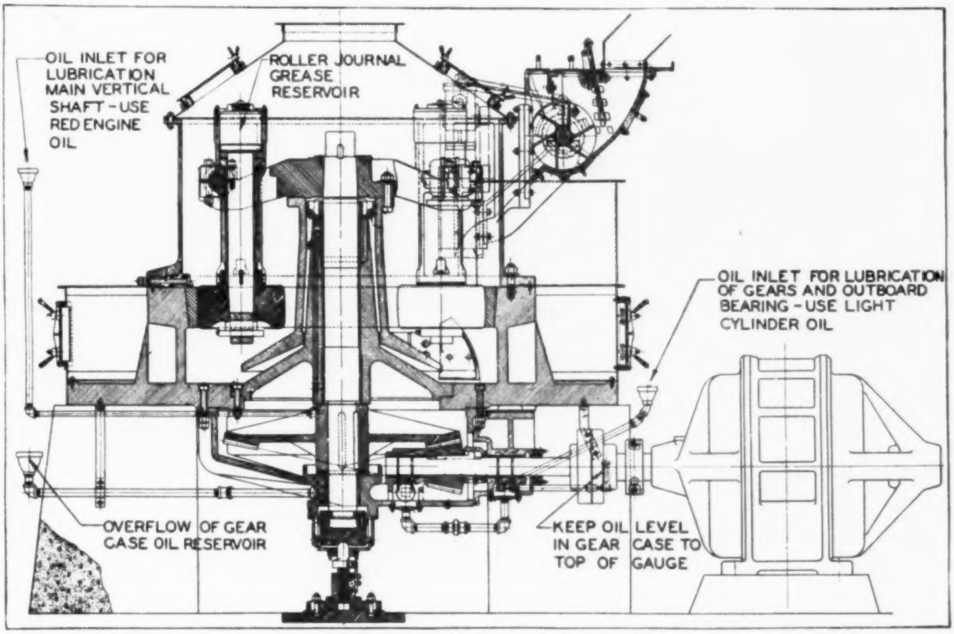
Where front feed is involved the grates slope towards the rear of the furnace, being set in one uniform plane. In the side feed furnace there are two sets of grates, each set sloping towards the center, making an angle or V at the lowest point.

In a stoker of this type certain of the grates move backward and forward with respect to each other, being actuated by kicker or rocking bars. This motion carries the fuel down the grates to the rear or center. All this time combustion is taking place, coking and the burning of volatile gases occurring while the coal is on the upper parts of the grate. When the coal has been carried to the clinker crusher or dumping device at the bottom of the grate or grates, it should have been completely burned and should then be ready for discharge as ash.

Overfeed stokers are adaptable to the firing of coking varieties of coal due to the motion of their grates which keeps the fuel bed porous and broken up, thus preventing caking or the formation of clinkers.

Chain Grate Construction

The Chain Grate or Traveling Stoker involves an endless chain which passes over suitable sprockets at the front and rear of the furnace, the meshed links or bars of this chain



Courtesy of Combustion Engineering Corp.

Fig. 2—Sectional view of the Raymond Super Roller Mill. Attention is drawn to the points of application of lubricants to the driving gears, the main vertical shaft and the roller journals.

Underfeed Design

Underfeed Stokers involve the introduction of fresh coal beneath the fuel bed by means of steam or electric driven rams or plungers. The coal is usually delivered through a gravity feed hopper to the several retorts in which these rams or plungers operate. Essentially these retorts are individual primary combustion chambers, the sides being either stationary or subject to reciprocating motion. These sides also serve to carry the tuyeres or air grates, the latter consisting usually of a number of superimposed perforated plates.

As fresh coal is fed into the retorts it is gradually forced underneath the fuel bed by the action of either the plunger alone or a number of automatic auxiliary distributing pushers or plungers. This movement of the base of the fuel bed, together with the continued air blast which is delivered through the tuyeres, insures against caking or any tendency towards dirty fires. The volatile gases are driven off as the fresh coal becomes hotter and hotter through its proximity to the fuel bed above, being burned as they pass through this heated area; the green coal meanwhile becomes gradually coked, and ultimately burned completely.

serving as the grate or fuel bed. This chain is in motion continuously, passing round and round through the furnace, taking fresh fuel at one end of the furnace and discharging the residual ash at the other, as the chain turns over the sprockets.

The necessary sprockets are fastened to suitable shafts which are part of the base frame of the stoker. Either the front or rear sprocket can be used as the driving element by suitable connection to a worm reduction gear mechanism, which in turn may be either driven by steam or electric power.

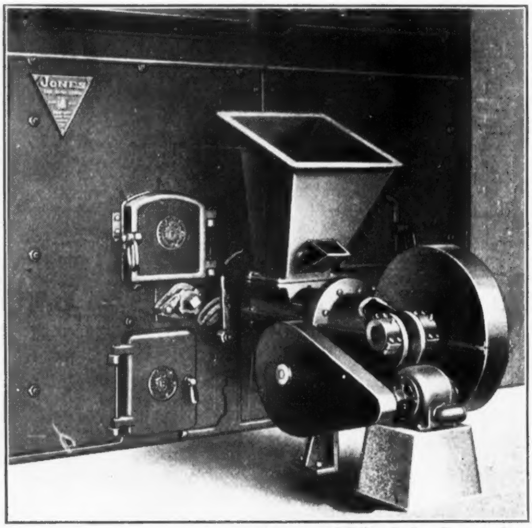
Coal is fed by gravity to the chain grate stoker in much the same manner as to the other types mentioned above; usually a suitable hopper is installed for this purpose at the front end of the furnace. The necessary air for combustion is delivered through the chain grate via either one or more distributing compartments below the top grate.

DESIGN OF WEARING ELEMENTS

With the unit type of pulverizers, as noted, equipment will be far more simple than where a bin or storage system is used. As a rule, the primary parts requiring lubrication will con-

sist of the bearings of pulverizers, motors, air fans and conveyors, and the essential driving gears.

Anti-friction bearings are extensively used to carry the main shafting of rotary pulverizers



Courtesy of Riley Stoker Corporation.

Fig. 3—Front view of a Jones Stoker equipped with a Riflex mechanical drive. It is interesting to note that spur reduction gears are involved in this drive for the operation of the plunger.

and the fan elements. The resulting tightness of the housings will effectively protect these parts against the entry of abrasive coal dust, dampness or perhaps metallic particles. This is naturally of extreme importance as an adjunct to lubrication, which on such equipment is essentially a matter of reducing the power requirements of the various gears and bearings which constitute the operating mechanism.

The fact that the primary purpose in burning pulverized coal is to increase steam generation per ton of coal by reducing waste of heat units through incomplete combustion, renders it equally important to extend our efforts to the wearing elements of all equipment involved, to reduce the amount of power consumed. Failure in either case would, to a more or less extent, discount any potential advantages which might accrue from the other.

Ring Oiled Bearings

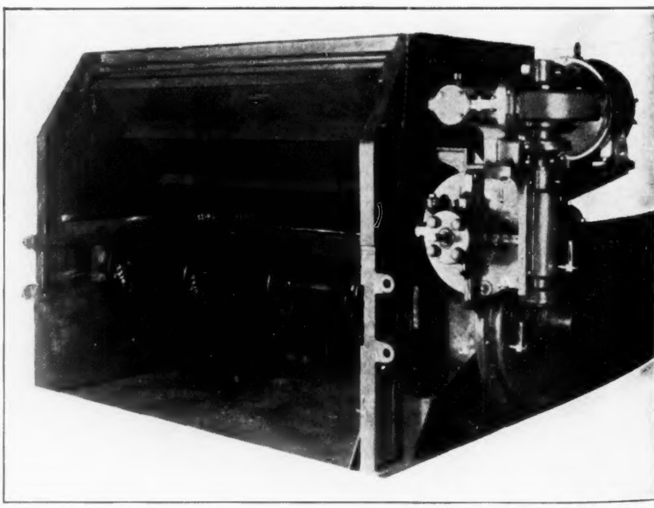
The principle of operation involved in the ring oiled bearing is the continual delivery of oil to the bearing surfaces by means of a ring which is suspended from the shaft. This ring dips into the oil which is contained in the reservoir, to a more or less extent according to the level at which the oil is carried.

In order to insure effective lubrication by means of a ring oiler it is important that the reservoir be of adequate capacity to give the oil ample opportunity to rest, thereby making possible not only the settling out of sediment and other foreign matter, but also cooling to the requisite degree. As a rule the only way in which the oil in such a system is kept at the proper temperature is by radiation of heat from the exterior surfaces of the reservoir or well.

Should this latter be of apparently insufficient capacity, at times it is possible to overcome this by fitting an auxiliary reservoir below the one in question. One way in which this can be done is to tap a short length of pipe into the lower part of the bearing, plugging the bottom end with a cap. Such a device has an added advantage in that it also acts as a dirt collector.

It is apparent that oil which is carried to the top of a ring-oiled bearing must be taken care of and returned to the reservoir as rapidly as it is delivered by the ring. If this is not possible, oil will tend to accumulate in the upper part of the housing to ultimately be forced out through the ends of the bearings.

The same condition may arise if the oil is carried too high in the well, or if the ring rotates at too high a speed. This will cause a splashing and churning of the oil.



Courtesy of Illinois Stoker Company.

Fig. 4—Front view of the drive and sprockets of the Illinois chain grate stoker. The feature of this drive is that it is a fully enclosed directly connected electric type.

Anti-Friction Bearings

Anti-friction bearings of the ball and roller type have proven extremely adaptable where certain requirements such as reduction in the amount of attention from a lubricating point

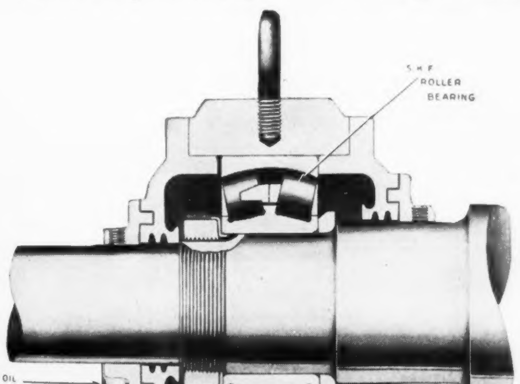
of view and positiveness of action must be observed. Ball bearings can be lubricated either with oil or grease according to the design of the bearing housings. Roller bearings can be similarly lubricated though the type and construction of the rollers must be considered in addition. The customary housing design affords ideal protection against the entry of contaminating foreign matter; as a result economy in lubrication is decidedly practicable.

From a constructional point of view, anti-friction bearings involve rolling contact as compared with plain bearings wherein sliding contact occurs. In ball bearings, this rolling contact is that of a theoretical point over a given surface. Roller bearings, however, involve theoretical line contact between the journal or shaft element and the outer raceway.

Driving Gears

The question of whether or not gearing will be involved in a pulverized coal machine will depend upon the design. There are certain types of mills wherein spur or bevelled gears are an essential as a means of bringing about the necessary speed reductions. There are other mills, however, wherein the coal pulverizing elements are directly connected to the driving motor.

Wherever possible, speed reduction gears are,

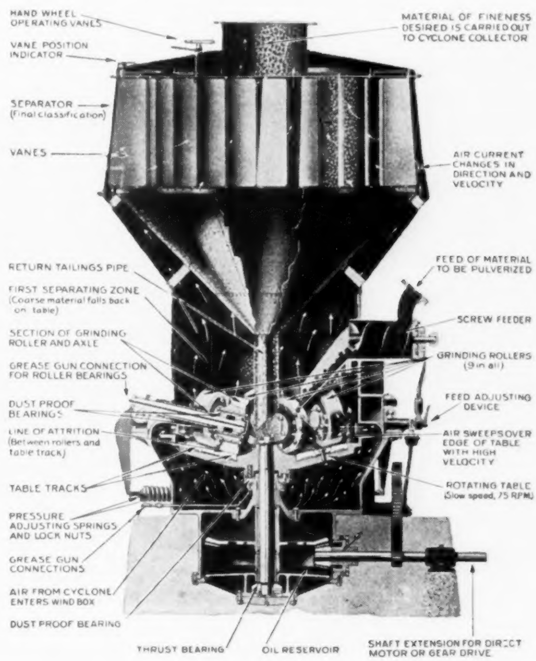


Courtesy of Foster Wheeler Corporation.

Fig. 5—Side view of a main bearing of an Aero pulverizer. Note that the shaft is carried by S. K. F. roller bearings. An interesting feature is the oil gauge whereby the oil level can be observed and maintained constant.

of course, enclosed in order to protect the teeth from the abrasive action of foreign matter, and also to insure that more effective and economical lubrication can be maintained. In mills of the vertical type, the driving gears are contained in a housing or case at the base of the machine, the gear shaft being carried in a step or thrust bearing which is very frequently lubricated by oil from the gear case.

On the other hand, it is not always practic-



Courtesy of Bethlehem Steel Company.

Fig. 6—Detailed view of the Bethlehem pulverizer, showing all essential parts. Particular attention is drawn to the fact that roller bearings are employed in the grinding roller. Another point of interest is the thrust bearing, and oil reservoir for lubrication of the driving gears.

able to enclose the driving gears, especially where these are of the girth type, with the main gear completely surrounding the pulverizing element, as is true in the case of certain types of ball mills.

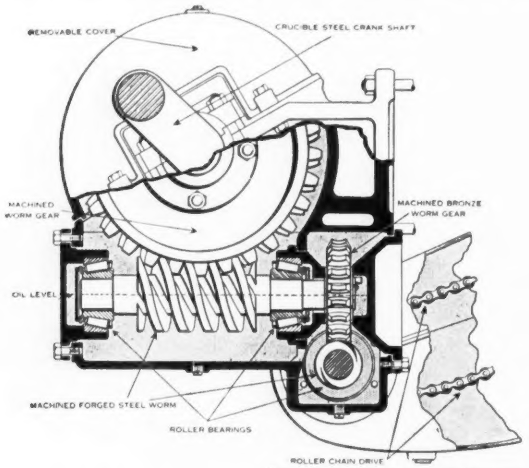
Manner of Lubrication

Where driving gears are properly housed in an oil-tight casing, it is a comparatively simple matter to maintain lubrication by merely carrying the oil level in the case at a proper height. Frequently, this is fixed by the installation of an overflow device.

For the lubrication of such gears, a product having a viscosity of from 100 to 200 seconds Saybolt at 210 degrees would normally meet all requirements. For average operation, if the lubricant is akin to a straight mineral steam cylinder oil, it will serve the purpose. There may be some instances, however, where operating temperatures will be comparatively high, or where heavy duty is involved, in which case it would be advisable to substitute a somewhat heavier lubricant, of a viscosity approximating the higher range, as stated above.

For the lubrication of exposed gears, it is of

course essential to use a product which will stick tenaciously to the teeth and not throw off or ball up, if contaminated by powdered coal, or other dust which may prevail around the plant. As a rule, such gears are lubricated with



Courtesy of Detroit Stoker Company.

Fig. 7—A stoker drive wherein the worm is located below the main gear. This arrangement readily permits of bath lubrication, using a relatively light bodied gear lubricant. Note the thrust roller bearings which are installed in the worm shaft. This drive is fully enclosed.

a product ranging from 500 to 1000 seconds Saybolt at 210 degrees F.

STOKER MECHANISMS

In order to manipulate the grates of the overfeed stoker, operate the plungers and rams of the underfeed machine, run the chain grate at the desired speed, and turn the clinker grinder, it is essential to use some form of reduction geared power unit. This is commonly either a small vertical reciprocating steam engine, a turbine or an electric motor. The several types of stokers on the market vary considerably in their methods of handling fuels just as they vary in regard to their driving mechanism.

Overfeed Stoker Mechanism

In the overfeed stoker the feature of operation is the rocking or reciprocating motion to which the grates are subjected. This is brought about by means of a kicker bar or rocker which receives its reciprocating motion from the driving unit through a crank, eccentric connection, or a series of toggle levers.

The Underfeed Stoker

The underfeed stoker in turn, depends upon the reciprocating action of the plunger in the charging of fresh fuel and the pressure of the air blast, for the agitation of the fuel bed. Therefore, the essential operating mechanisms involved are the plungers and the coal feeding devices.

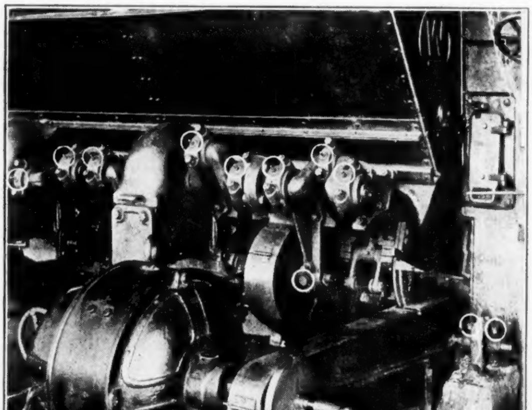
The plungers and distributing rams are usually connected to the driving unit through a suitable crank shaft of heavy construction. The driving unit can also be further connected through crank, link or rod mechanisms to operate a clinker grinder if necessary, and also the reciprocating overfeed grates and retort side bars in some types of stokers. As a result a regular sequence of operation is maintained in all the necessary moving parts just as long as the driving unit is running and the proper connections are maintained.

Chain Grate Operation

The principal operating part in the chain grate stoker is the driving mechanism. As has already been stated this may be attached to either the front or rear sprocket shaft through suitable reduction gearing. Additional mitre gears in connection with adjustable ratchet mechanisms are also used on some front feed stoker drives for the purpose of regulating the coal feeding device. In other types of such stokers a hand wheel operated worm and gear device is used for the controlling of the coal feed from the hopper onto the stoker chain. The sprocket shafts are carried in pedestal bearings of suitable size and construction to meet the wearing conditions and enable the requisite lubrication.

LUBRICATION REQUIREMENTS

A most important factor in the lubrication of any mechanical stoker drive, or the bearing



Courtesy of Westinghouse Elec. & Mfg. Co.

Fig. 8—Front view of a Westinghouse stoker drive showing in particular the means for grease lubrication of the essential bearings. Note that both compression grease cups and automatic pressure gun fittings are used for this purpose.

elements of a coal pulverizer, is to understand the lubricating requirements under operation. Essentially, this involves a realization of the temperatures and pressures which may prevail, and the possibility of contamination of lubri-

cants by abrasive foreign matter such as coal dust or ash.

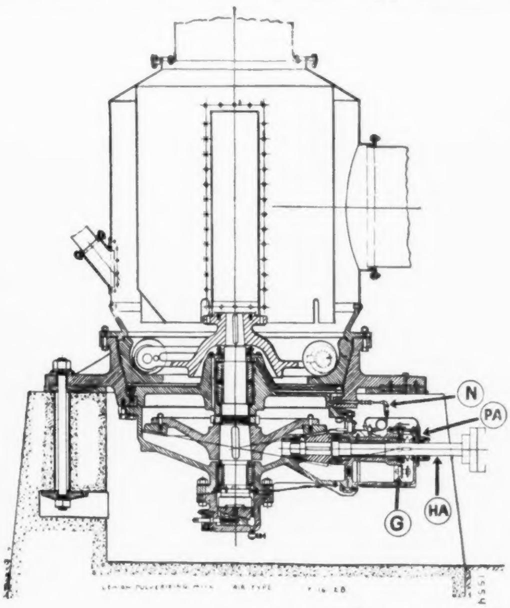
In the Pulverizer

The functions of lubricants on practically all wearing elements involved in pulverized coal burning equipment are twofold:

(a) To lubricate, that is to reduce metallic or solid friction to a minimum by the maintenance of a film of fluid oil between the bearing surfaces or other surfaces in motion with respect to one another; and

(b) To protect these surfaces from scoring or abrasion, by preventing entry of foreign matter such as coal dust.

Resultant friction, or the braking element which determines the amount of power required to operate any part of the machinery is reduced by substituting the fluid friction of oil for the solid friction which would otherwise occur between any two solid surfaces in motion with respect to each other. Fluid friction is far lower than solid friction, therefore, continued operation at high speeds is possible, provided of course, that this film of oil is maintained in unbroken condition by proper application of



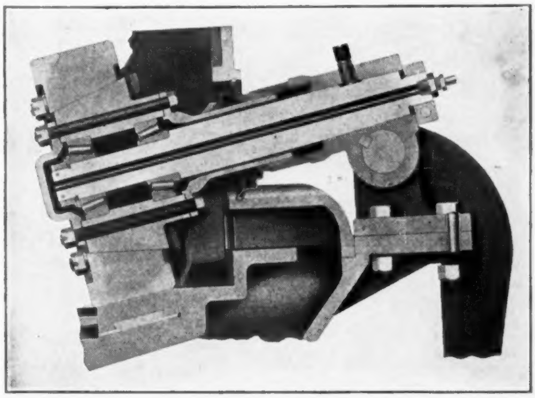
Courtesy of Fuller Lehigh Company.

Fig. 9—Sectional view of the Lehigh air separator pulverizing mill. The oiling system involves an oil pump "G", driven by a chain from the main driving shaft "HA". As oil is discharged through a strainer it passes to the upper and lower main shaft bearings. The connection to the upper bearing is through an oil riser. This latter in turn is connected to the upper main shaft bearing by tube "N" which has a sight feed indicator in the line to the gear and pinion teeth, and to the oil seal in the end cover "PA" on the pinion shaft.

fresh lubricant. In this way temperatures are also kept within safe limits during operation.

In turn by selecting lubricants of such body or viscosity as to remain in bearing clearance spaces or upon the surfaces of gear teeth for a reasonable length of time, not only will economy of lubrication be attained, but also will entry of foreign abrasive matter via any exposed bearing ends be prevented.

The fact that lubrication plays so important



Courtesy of Bethlehem Steel Company

Fig 10—Sectional view through the grinding roller of a Bethlehem pulverizer, showing the roller arm and support. Note the provision for grease gun lubrication through the center of the arm.

a part in the attainment of economical pulverized fuel equipment operation requires a rather detailed discussion of bearings and their constructional details. It can be appreciated that unless we have a knowledge of the lubricating requirements of various types of bearings, it would be a difficult matter to determine correctly the proper grade of oil or grease to use.

In addition, the types of lubricating systems must also be understood. Both oil and grease in their proper consistencies are ideal lubricants; they must, however, be adapted to the systems of lubrication and the construction of the bearings. In many cases either one would give satisfactory service; unsealed bearing construction, the prevalence of temperature fluctuations or abnormal clearances, however, might markedly influence resultant economy. Therefore all these conditions should be considered when selecting such lubricants.

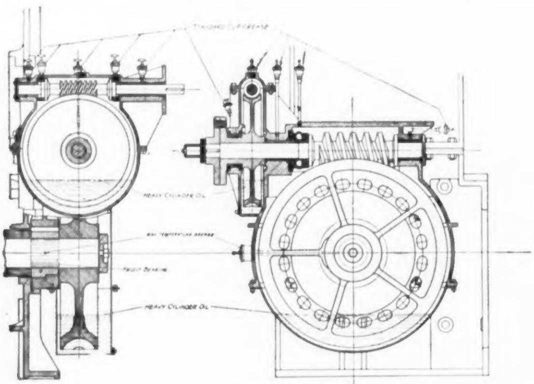
Where Anti-Friction Bearings Are Involved

The purpose of lubrication in the above is to facilitate as easy rolling as possible. To enable this, however, all the surfaces (which are of a highly polished nature) must be in as perfect condition as practicable. The lubricant must therefore serve the dual purpose of both lubricating, and protecting these surfaces against rusting, corrosion, pitting or abnormal wear.

Minimum clearance of course is an aid to proper functioning of such bearings, for the occurrence of any play between the component parts would tend to set up a certain amount of action which would be detrimental to effective operation. In other words, all motion must be as nearly akin to perfect rolling as possible.

Stoker Drives

The mechanical stoker in turn will require consideration of lubrication of its speed reduction gears, the miscellaneous bearings of the accessory connections which serve to operate the movable grates, etc., the pedestal and other more important bearings of both chain grates and underfeed stokers and the driving engines, turbines or electric motors.



Courtesy of The Babcock & Wilcox Company.

Fig. 11—A worm reduction geared stoker drive, wherein the worm is located above the main gear. This design is enclosed in an oil-tight casing, to permit of bath lubrication. All bearings are grease lubricated as shown.

In general, these elements and their lubrication can be regarded from four broad viewpoints, dependent upon the type of wearing parts involved. These will comprise

1. Reduction gears,
2. Chain drives,
3. Bearings, and
4. Steam cylinders.

While many of the moving parts of any type of mechanical stoker are exposed to a certain amount of heat, those parts which require lubrication are generally subject to comparatively average boiler room temperatures. These latter, however, may often be sufficiently abnormal to render lubrication a serious problem. Bearings of movable grate connections as a rule will be chiefly affected in this respect. Other operating parts being outside the furnace, receive only the heat of radiation from the boiler.

CHARACTER OF LUBRICANTS TO USE

In deciding upon the type of lubricant to select for any specific wearing part of the average stoker or pulverizer, it will also be essential to consider the design and the means provided for lubrication.

Ring Oiling Requirements

Where ring oilers are involved, lubrication can normally be satisfactorily maintained by use of a high grade straight mineral oil of approximately 150 to 200 seconds Saybolt at 100 degrees Fahrenheit.

In determining upon the viscosity of such an oil, the bearing construction should be investigated; oftentimes if oil returns are too small they may become clogged, causing heavier oils to overflow.

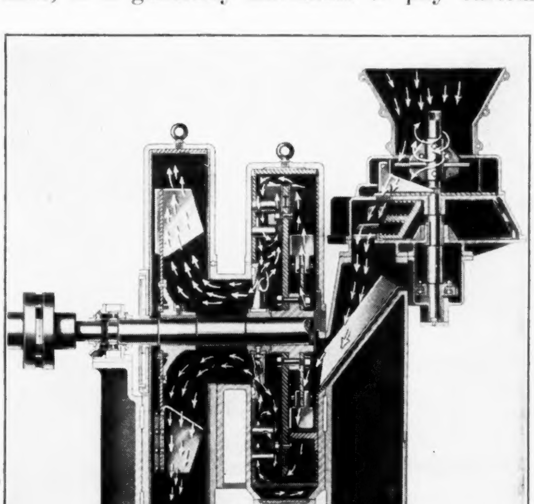
By virtue of the fact that certain equipment may frequently be called upon to function under abnormally low temperatures, an oil with a low pour test should be chosen wherever possible. If this latter approximates zero degrees Fahrenheit the oil will generally function satisfactorily.

On the other hand, higher temperatures will oftentimes require additional viscosity to resist the thinning down action of heat. Under such conditions, an oil of from 300 to 500 seconds viscosity or even higher may be advisable.

Viscosity Required for Ball Bearings

As a general rule, as light a lubricant should be used in a ball bearing as can be successfully retained in the bearing housing, commensurate with the temperatures and pressures involved. Usually an oil with a viscosity of from 100 to 200 seconds Saybolt at 100 degrees Fahrenheit, will be best.

To reduce the possibility of the development of abnormal internal friction within the lubricant, it is generally advisable to pay careful attention to the oil level. Submergence of approximately one-half to three-quarters of the lowest ball will normally be sufficient. In this connection it is important to remember that contrary to the principles of plain bearing lubri-



Courtesy of Riley Stoker Company.

Fig. 12—Sectional view of the Riley Atrita unit pulverizer, showing path of coal in the process of pulverization. This latter is brought about by swing hammers.

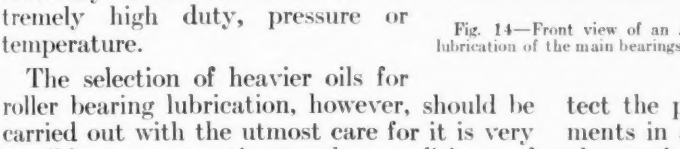
cation, the oil in a ball or roller bearing plays no part as a coolant. Therefore volume is a detriment rather than an advantage.

Roller Bearings

Roller bearing lubrication by means of oil is subject to much the same conditions as stated in connection with ball bearings. Where end thrust may develop to an appreciable extent, however, due to difficulty in keeping the rollers in alignment, or where pressures or temperatures may be high it is the opinion of certain authorities that it will be conducive to better lubrication if somewhat heavier oils are used.

Under such conditions the use of straight mineral lubricating oils of as high as 750 seconds Saybolt viscosity at 100 degrees Fahrenheit are advocated. Mineral cylinder oils of a high degree of purity may even be necessary under conditions of extremely high duty, pressure or temperature.

The selection of heavier oils for roller bearing lubrication, however, should be carried out with the utmost care for it is very possible to over-estimate the conditions of operation, with the result that an excess of internal friction may be developed. As a rule careful observation of operating temperatures, and cooperation with the bearing manufacturers and the petroleum industry as to the proper grade of lubricant for any such condition, will insure satisfactory results.

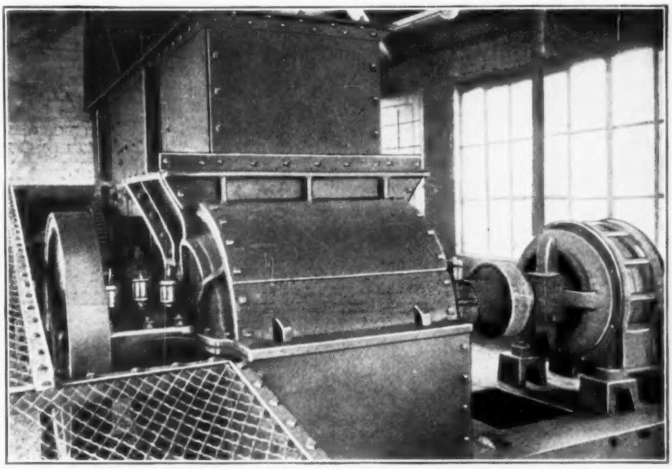


Courtesy of Erie City Iron Works.

Fig. 13—Open view of a motor-driven Erie City unit type pulverizer, showing arrangement of paddles for three-stage pulverization. Note the provision for grease lubrication at each end of the main shaft.

Where Grease Should Be Used

Wherever there is possibility of oil leakage, or under conditions of dust, dirt or dampness, abnormal pressure or high temperature, it may be advisable to use grease as the lubricant. Greases furnish better seals against the entry of dust, dirt and moisture thereby serving to protect the polished surfaces of the bearing elements in a very satisfactory manner. Grease also can be very much more effectively retained in a non-oil-tight housing; on the other hand, dirt or grit that finds its way into a grease lubricated bearing, has no means of settling out, but is frequently held in suspension, being carried back into the bearing repeatedly.



Courtesy of American Pulverizer Co.

Fig. 14—Front view of an American pulverizer, showing provision for grease cup lubrication of the main bearings.

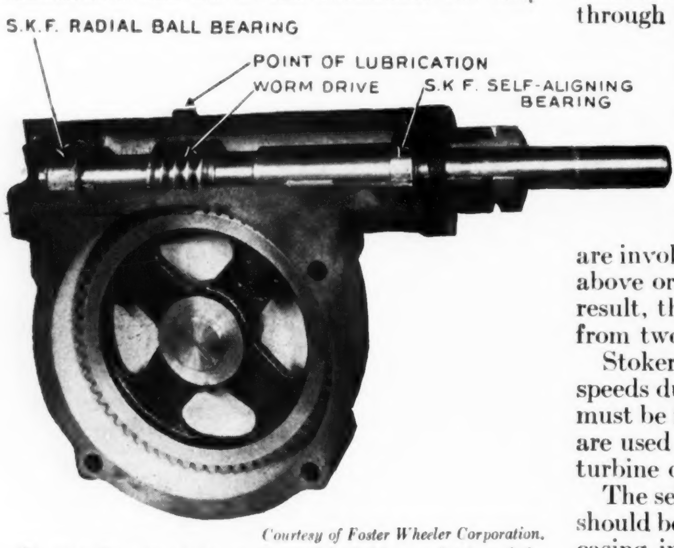
As a general rule, products of comparatively light consistency will meet average operating conditions where the lubricant must readily cover the entire surfaces of the rolling elements and not tend to channel in the housings or raceways, as might occur with more viscous products of this nature which would have less of a penetrative ability.

On the other hand, under conditions of extra high temperature, it might be necessary to resort to greases of greater body to withstand the thinning-out effects of heat, and prevent the consequent entry of dust, dirt, or other contaminating foreign matter.

Steam Cylinders

In view of the fact that certain types of stokers may be equipped with vertical, reciprocating, enclosed crankcase steam engines, which are usually of the single acting type, a few words regarding their lubrication will be of interest.

In the lubrication of certain of these engines the design not only does not aim to prevent the entry of water but actually makes use of this latter as a carrier for oil. During the process of lubrication the oil in the crankcase not only serves the bearings, but also the cylinder walls, cooperating in this latter with the oil which is fed in with the steam.



Courtesy of Foster Wheeler Corporation.

Fig. 15—Top view of the worm geared feed drive mechanism of the Aero pulverizer. Note that the main shaft is mounted on S. K. F. ball bearings. Pressure grease lubrication is provided for.

To insure effective lubrication the crankcase must be filled with water (preferably condensate) to the level of the overflow pipe. On top of this body of water is carried a one-quarter inch film or layer of specially refined lubricating oil. As the crank disc dips into this the requisite amount of lubricant is thrown to the cylinder walls, and internal bearings. The purpose of using a mixture of oil and water for lubrication is to enable the attainment of a more effective distribution of the oil than were the latter to be used alone.

It is possible, furthermore, to bring about lubrication of both cylinders and bearings by means of one oil, and that a heavier product than would normally be used for other splash feed systems. Usually this oil should have a viscosity in the neighborhood of 100 seconds Saybolt at 210 degrees Fahrenheit. It must separate readily from water, yet it must have sufficient adhesive ability to render it capable of clinging to the cylinder walls in the presence of water.

Emulsification to a very slight extent does no harm, but there is always possibility of repeated churning causing thick emulsions or "livering," especially if too much oil is used or if it has not been sufficiently carefully refined and prepared. Emulsions will frequently tend to render the lubricating system inoperative. They must, therefore, be carefully guarded against.

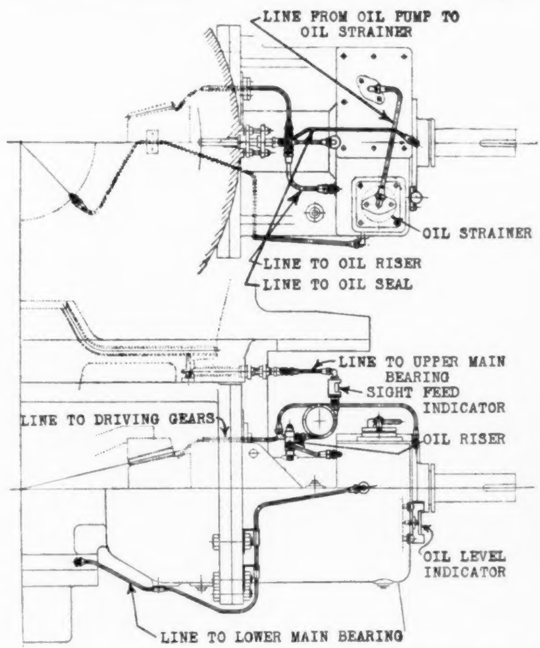
Main bearings of such engines are usually lubricated by sight feed oil cups. The valve mechanism is in turn lubricated as necessary through hydrostatic or force feed oilers using oftentimes the same grade of oil as in the crank case.

Reduction Gears

Worm and spur gears are other important parts from the view-point of lubrication. According to the type of machine, where worm gear drives are involved, the worms may be located either above or below the main driving gears. As a result, their lubrication requires consideration from two angles.

Stokers especially will normally run at low speeds due to the gradual rate at which the coal must be fed. As a result large speed reductions are used especially where the prime mover is a turbine or an electric motor.

The selection of the lubricant for such a drive should be based primarily upon the type of gear casing installed. In other words, an oil tight casing will enable the employment of bath lubrication and the use of a lubricant of just sufficient viscosity to preclude wearing of the teeth. Where but a safety gear shield or an open or leaky case is involved, naturally we must turn to the heavier, more plastic grades of lubricants.



Courtesy of Fuller Lehigh Company.

Fig. 16—Showing the essential details of the oiling system of the Lehigh air mill, as illustrated in Figure No. 9. Each point of lubrication is clearly indicated.

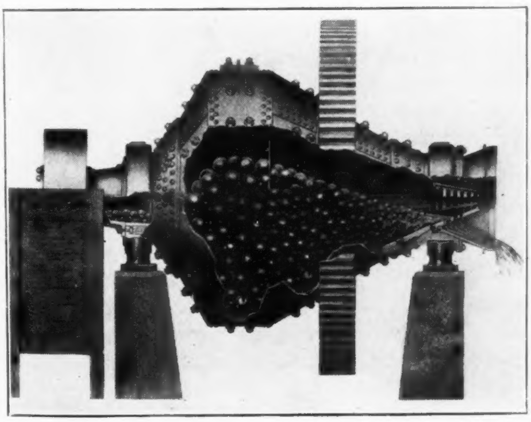
Worm Gear Requirements

Worm gear operation requires a lubricant of comparatively heavy viscosity and sufficient adhesiveness to resist being wiped off the teeth when subjected to their combined sliding and rolling action. It must be remembered that in many installations the same lubricant must not only serve to lubricate the gears but also the worm shaft thrust bearings. Inasmuch as the lubricating requirements will differ considerably, in such cases it will be necessary to compromise and use a lubricant as suitable to both as possible. Usually a straight mineral product of about the consistency of steam cylinder oil will meet the conditions.

The location of the worm with respect to the gear is important not only from the viewpoint of selection of the grade of lubricant, but also as to the manner of lubrication. When the worm is located below the gear it should be submerged to approximately the center line of the worm shaft. This will insure the transference of sufficient lubricant to the gear teeth as they mesh with the worm.

This condition will not exist to the same extent, however, when the worm is above the gear, due to the lower surface area of the gear teeth, and the fact that the lubricant may tend to travel along the worm shaft and drip down outside the trough. Also, especially when the drive is first started up there will be a possibility of an insufficient film of lubricant being carried by the gear teeth to the worm.

To forestall these conditions, it is advisable to run the gears submerged in lubricant to the full depth of their lower teeth using a highly adhesive, though relatively fluid product which will stick tenaciously to the tooth surfaces and not drip off even where radiated heat may be relatively high.

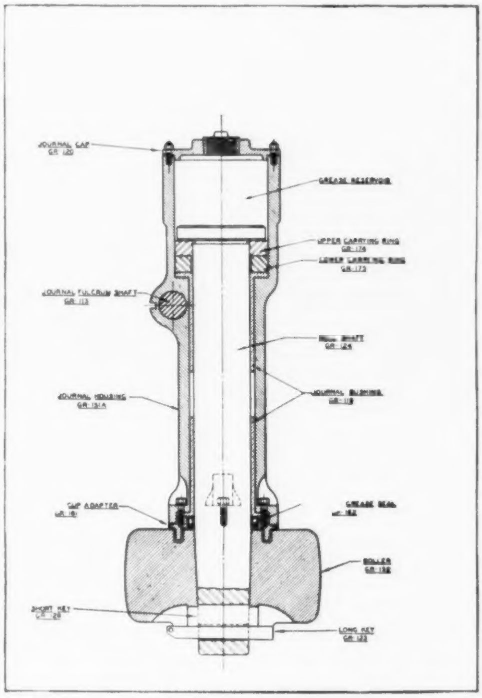


Courtesy of Hardinge Company.

Fig. 17—Cut-away view of a ball mill showing in particular the exposed girth gear. Lubrication of such gears must be carefully carried out.

Spur and Bevel Gear Drives

Where pulverizers or stokers are equipped with spur or bevel gear drives, these latter will in general be adequately enclosed in a suitable housing or base reservoir which will enable the use of more fluid lubricants than sometimes used in a worm reduction gear installation.



Courtesy of Combustion Eng. Corp.

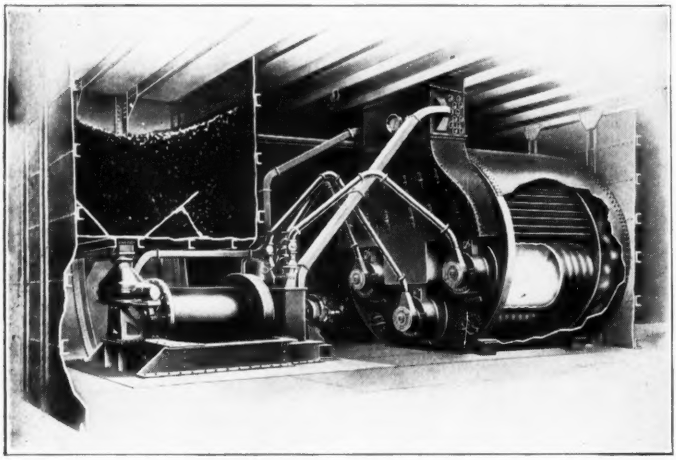
Fig. 18—Detailed view of the journal of a Raymond super mill. Note that the particular construction provides for grease lubrication, via a suitable reservoir at the top. Path of grease is by gravity from this reservoir to the clearance space between the roller shaft and journal bushing.

In certain of such installations a straight mineral oil of about 750 seconds Saybolt viscosity and 100 degrees Fahrenheit will often suffice. In others, where higher pressure, vibration or slow speeds are involved a heavier lubricant capable of adhering tenaciously to gear and pinion teeth should be used. Here an oil having a viscosity of approximately 100 to 150 seconds Saybolt at 210 degrees Fahrenheit will be best.

Exposed Gearing

When gear drives are not enclosed in an oil-tight casing bath lubrication is usually precluded, and it becomes necessary to apply the lubricant by hand, in heated condition, by means of a brush. In such instances the lubricant must be of considerably higher viscosity than specified above since it must maintain a suitable film on the teeth for a considerable period of time.

Low viscosity oils or non-adhesive greases will drip off when thinned down under the higher temperatures encountered. For such gears it is therefore advisable to use a straight mineral gear lubricant of approximately 500 to 1000 seconds viscosity Saybolt at 210 degrees Fahrenheit. Dirt and dust must also be considered when lubricating reduction gears of this type. Therefore, frequent attention should be given to cleaning the entire mechanism, otherwise excessive wear may occur due to the presence of abrasive material in the lubricating film on the teeth.



Courtesy of Kennedy-Van Saun Mfg. & Eng. Corp.
Fig. 19—Illustrating the application of the Kennedy tube mill system of pulverized coal burning to marine service.

Location of Stoker Bearings

Bearings in a stoker installation are internal and external in location. Internal bearings usually get little or no lubrication; in fact they are generally built with relatively high clearances, to operate without oil. The amount of motion to which they are subject is relatively slight, as is also the comparative rubbing speed.

External bearings, however, should receive careful attention. Frequently they are designed for grease lubrication, being equipped with suitable grease cups, or fittings for pressure lubrication.

Such means of lubrication is advantageous in that it is usually dustproof and insures a supply of clean lubricant to the bearing surfaces. Grease also tends to work out toward the end of the bearing, thus preventing the entry of dust along the shaft. For such service a medium bodied compression cup grease free from thickeners or non-lubricating adulterants will function satisfactorily.

It is also important to remember that in certain stokers the bearings of at least part of the gear shafting involved will be designed for lubrication by the same lubricant as serves the gears.

This materially simplifies the problem from a labor point of view, and also insures the bearings of more positive lubrication than where periodic attention is necessary. It necessitates, however, more careful selection of the lubricant, for the requirements of both gear teeth and bearings must be adequately met.

Where it is desirable to use the same oil for the external bearings of both the prime mover and the stoker, a medium viscosity engine oil of from 300 to 500 seconds viscosity Saybolt at 100 degrees Fahrenheit will be suitable.

Pulverizer Vertical Roll Shaft Lubrication

In the operation of certain types of vertical pulverizers a problem is often involved in the maintenance of lubrication of the roll shaft bearings. Pressures on these bearings may be comparatively high, some rollers weighing as much as seventeen hundred pounds.

Where grease is used, the course of the lubricant is by gravity from the reservoir in the top of the journal housing, to the clearance space between the shaft and its bushing. This clearance is comparatively low, for rigidity in the operation of such rolls is important.

As a result, the lubricant must be capable of constantly maintaining an effective film within the clearance space; furthermore, it should not tend to leak past the grease seal at the base of the bushing.

It is practicable to use either grease or oil for the lubrication of the above. Construction of many mills of this type calls for grease lubrication, the procedure being to fill the reservoir at the top of the housing at regular intervals, depending upon the nature of the grease, the extent of vibration and the operating temperature. As a general rule, a fairly solid grease will best serve the purpose, especially if its oil content is of sufficiently high viscosity to insure a lubricating film capable of withstanding the pressures involved, and any vibration which may be developed.

Where it is desirable to use oil as the lubricant, provision for storage and adequate delivery or circulation to the roll shaft bearings will be necessary.

Printed in U. S. A. by
Edgar C. Ruwe Co., Inc.
72 Washington St., N. Y. C.